



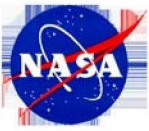
Delay/Disruption Tolerant Networks (DTN): Testing and Demonstration for Lunar Surface Applications

October, 2010

Patrick Fink, NASA

Kevin Hames, Phong Ngo (NASA)

Gary Grobe, Richard Barton (NASA/ESCG)



Background

- **A surface analog for wireless infrastructure is under development**

The analog will provide for connectivity between multiple analogs and facilities on site at JSC

- Wireless Habitat Test Bed
- Habitat Test Bed (HaT)
- Habitat Demonstration Unit (HDU)
- Lunar Electric Rover (LER)
- Lunar Rock Yard
- Operations Technology Facility (OTF)
- Electronic Systems Test Laboratory (ESTL)

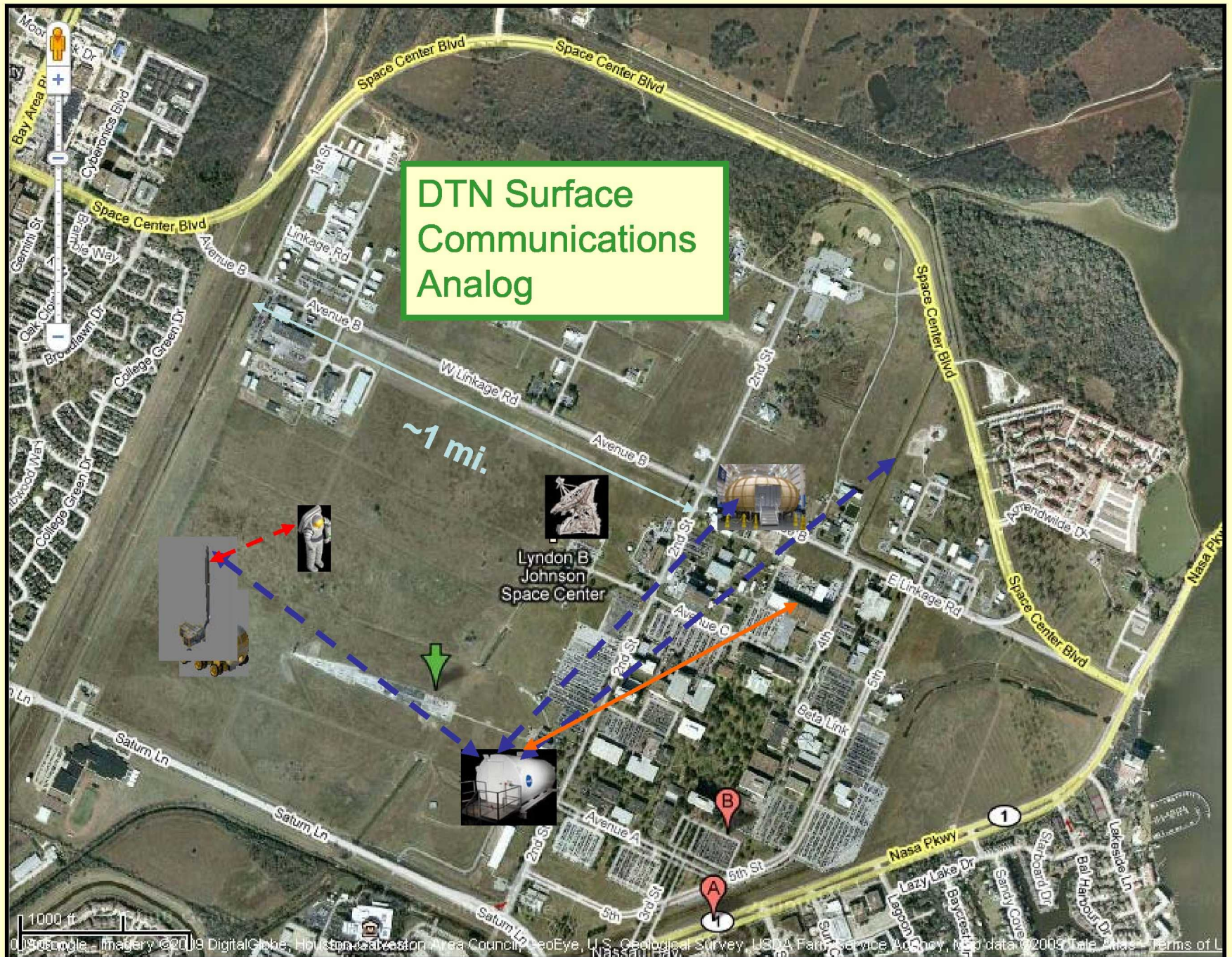
- **DTN Experimental Network (DEN) permits access and testing by other NASA Centers, DTN Team Members, and protocol developers**



Objectives

- **Demonstrate DTN for high return applications in lunar scenarios**
 - Different data types (video, audio, files, command & control)
- **Provide DEN connectivity with analogs of Constellation elements, emulators, and other resources from DTN Team Members**
- **Serve as a wireless communications staging ground for remote analog excursions (e.g., Desert-RATS)**
- **Enables testing of detailed communication scenarios and long term evaluation of network performance**
-

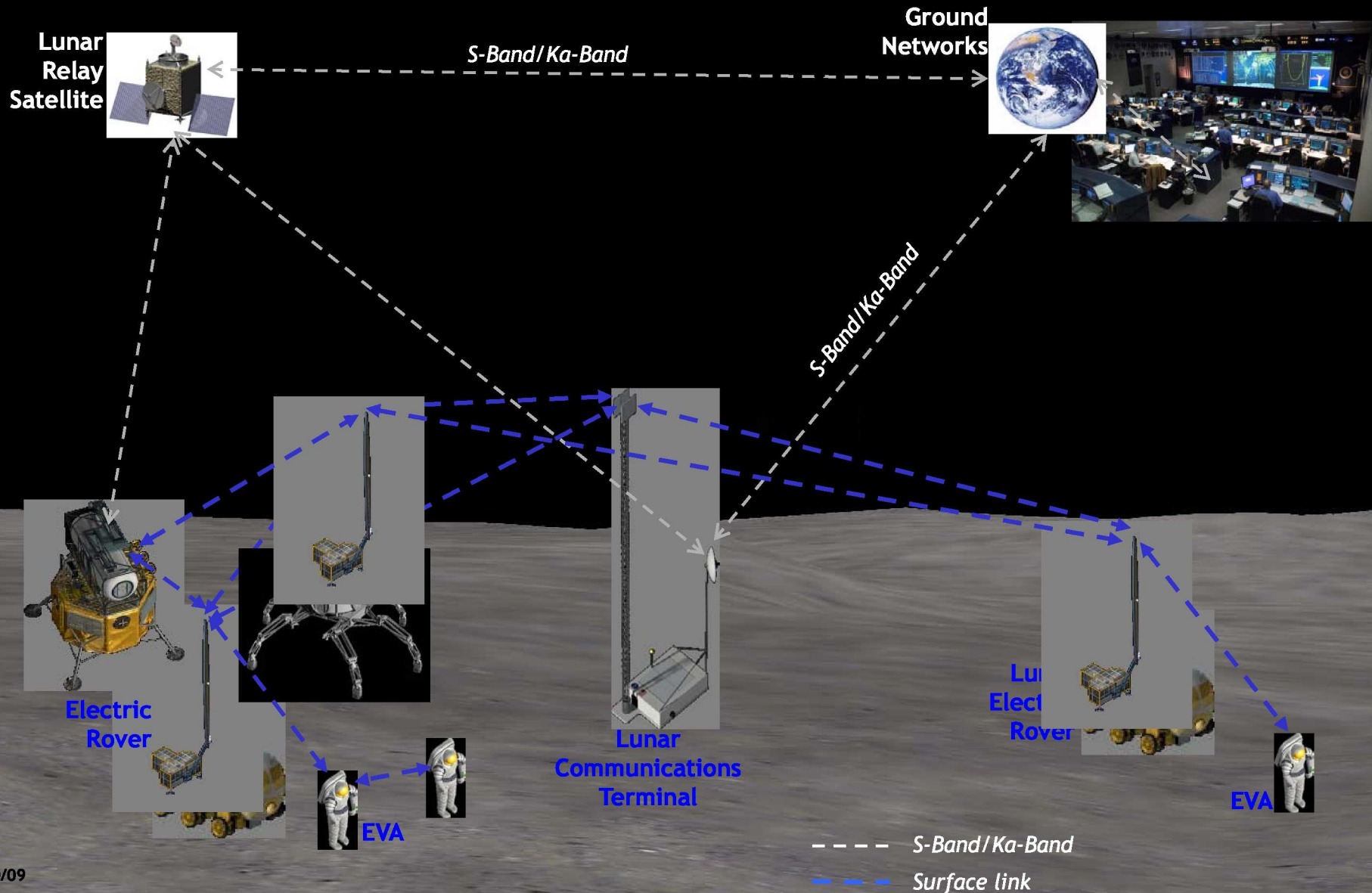
DTN Surface Communications Analog





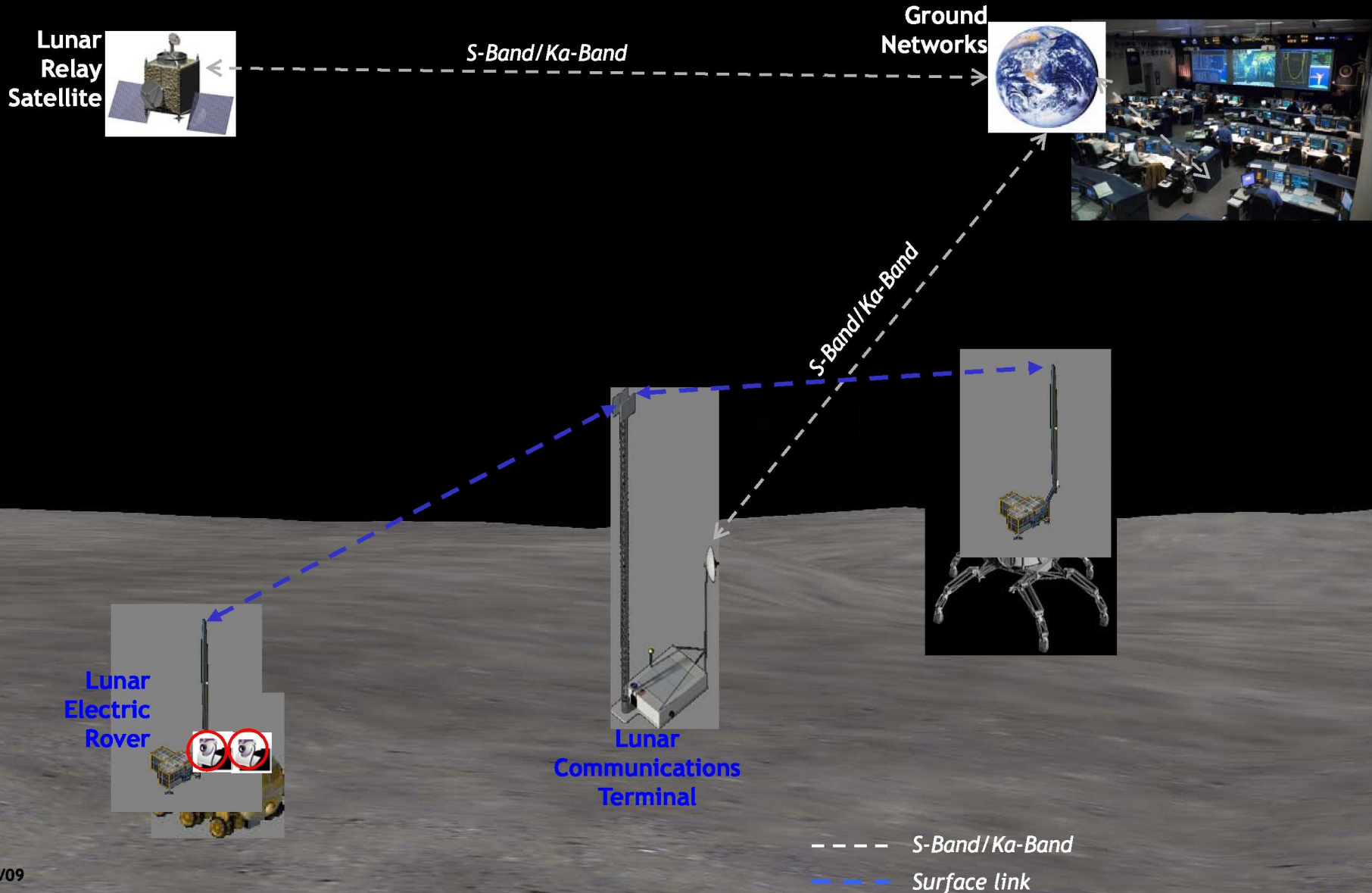


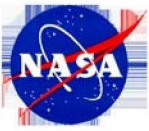
DTN Lunar Scenarios: Assets & Links





DTN Lunar Scenario: Rover Motion Imagery





DTN Lunar Scenario: Rover Motion Imagery Operations Concept

- **6-8 HD cameras mounted on each rover**
 - 1 camera per rover selected as “primary”, others “secondary”
 - Rover operators will switch between cameras while driving
 - Second rover may swap motion imagery with first rover
 - Ground operators will select camera(s) for downlink to Earth
 - Front camera for navigation and hazard avoidance
 - Need to know where EVA is with respect to rover – no vehicle-pedestrian accidents
 - Side cameras for situational awareness
 - Minimum 1 motion imagery stream while under way
 - All motion imagery stored locally for later forwarding



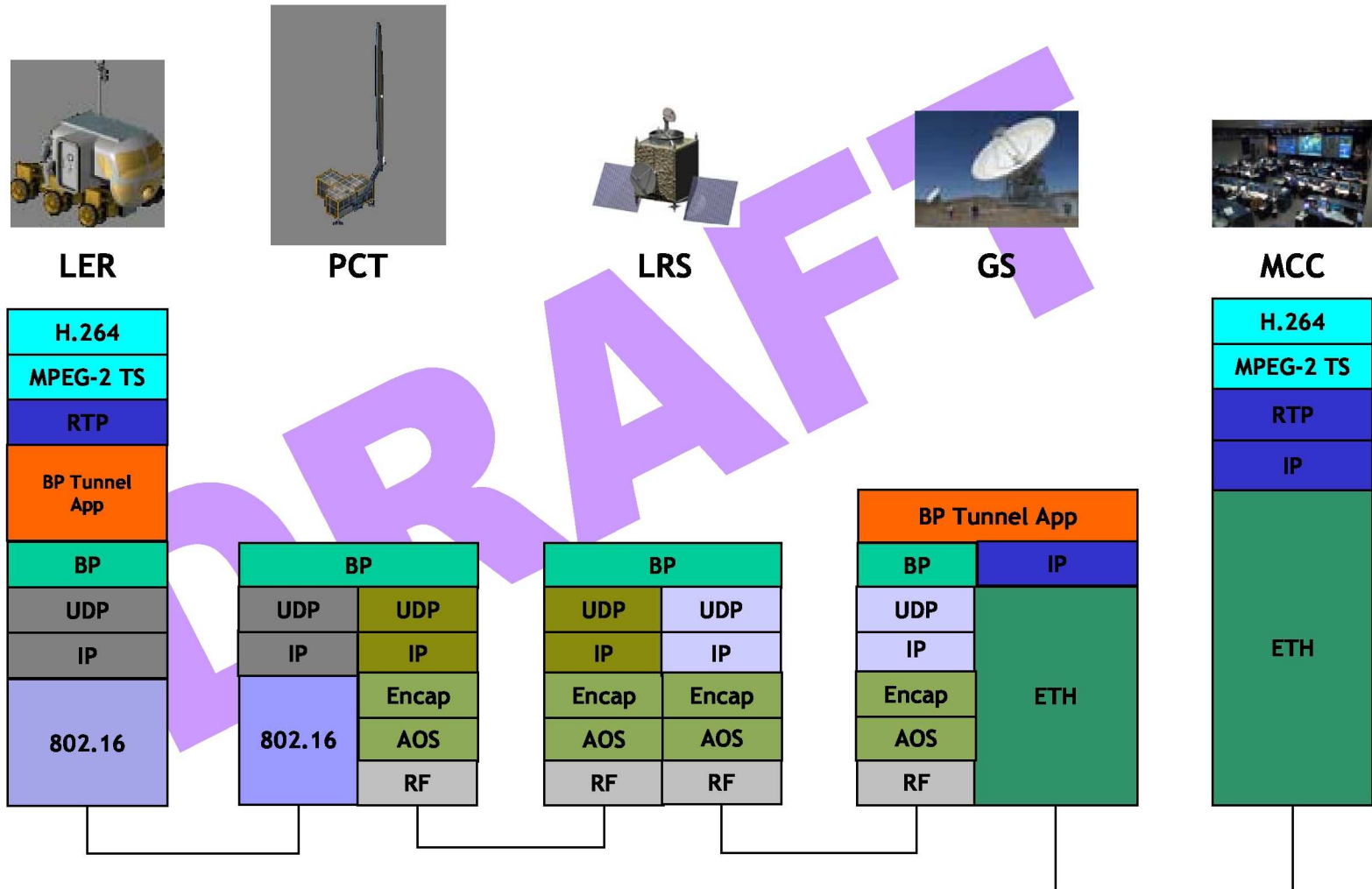
Motion Imagery Scenario: DTN Value

- **Surface communication infrastructure does not have to support real-time peak loads**
- **Data is not lost when channels are over-subscribed**
- **Increased video quality for science, public interest**



Motion Imagery Data Flow

Rover Communications Stack Diagram





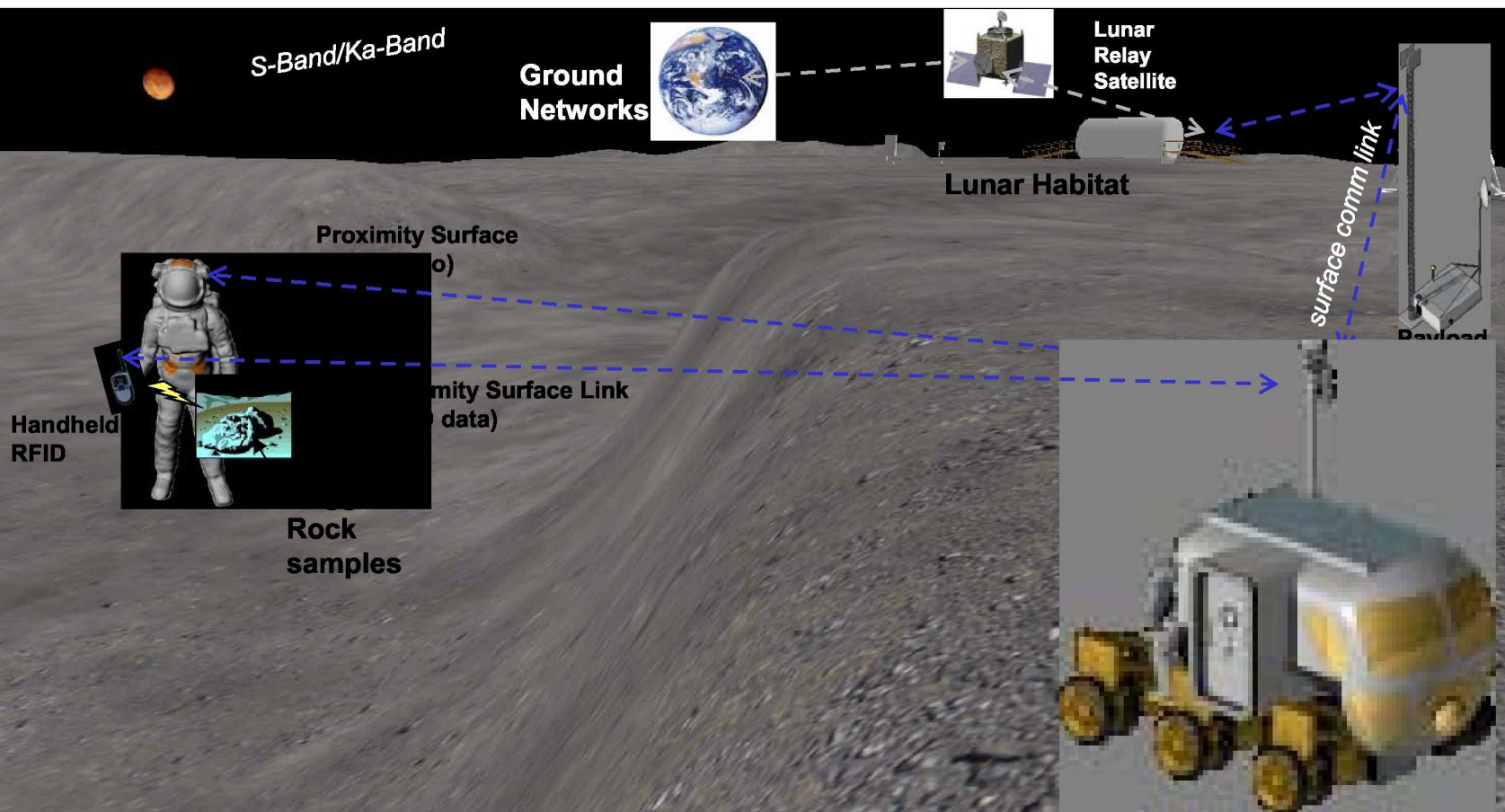
Motion Imagery Scenario at Surface Analog

- Single motion imagery stream to lunar communications terminal (rover collision avoidance – Screen 1)
- Second rover video is stored via DTN for later forward (Screen 2)





DTN Lunar Scenario: Voice Transcript/RFID





DTN Lunar Scenario: Voice Transcript/RFID Operations Concept

- **EVA traverses up to 100 meters from the rover**
- **EVA reports geologic setting and conditions on audio channel**
 - Audio transcript constitutes part of the scientific record for geologic specimens
- **EVA collects geologic specimens and places in bags**
- **RFID interrogator captures bag ID**
- **Audio and specimen ID are transmitted to the rover, which associates a location estimate with the data**



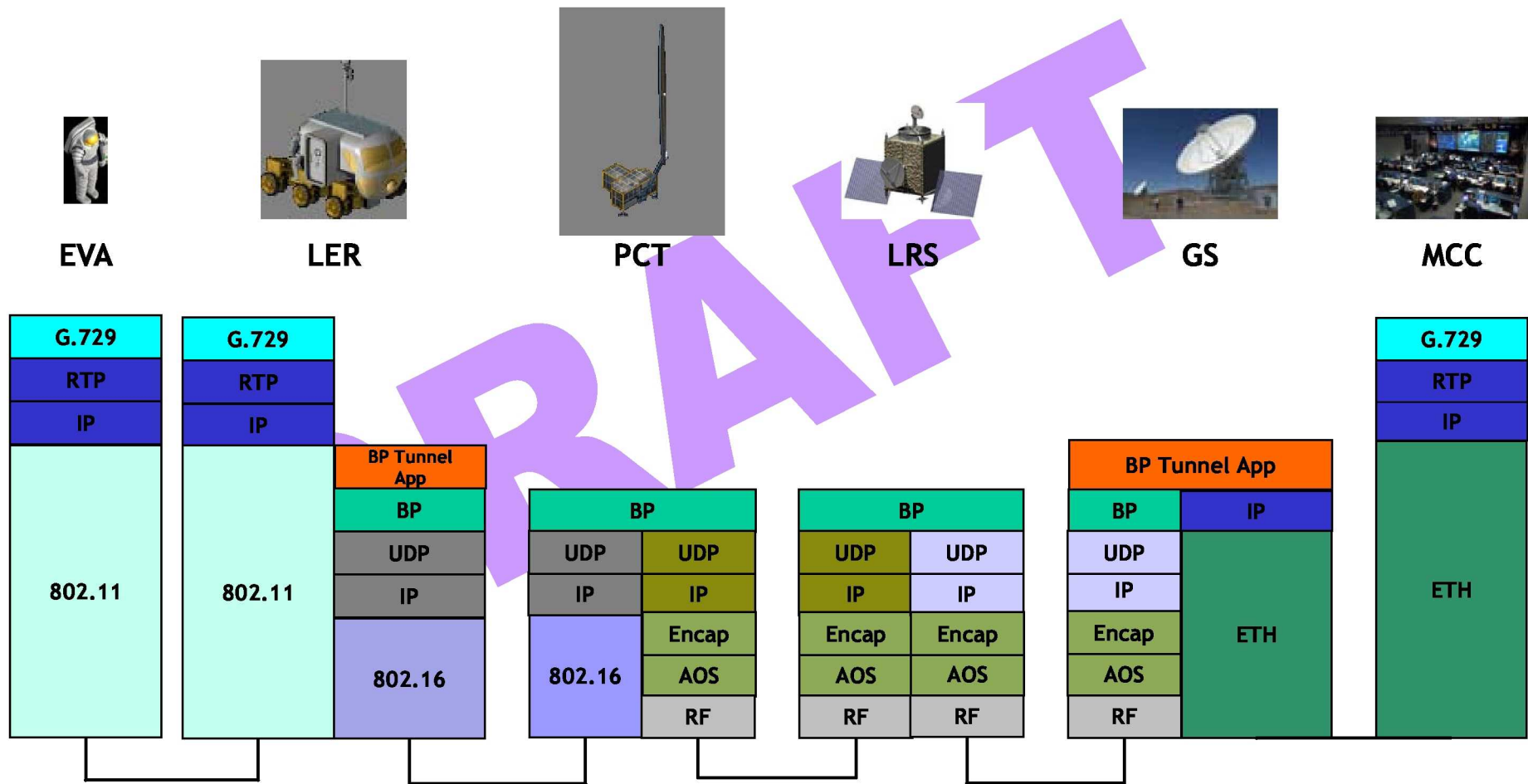
Audio/RFID Scenario: DTN Value

- **RFID data from the specimen bag, audio transcript, and coordinates are associated with each sample**
- **All of these constitute part of the scientific record**
- **Scientific field data is vulnerable to link disruptions along any segment of a multi-hop network**
- **DTN prevents loss of science**



Audio Data Flow

EVA Communications Stack Diagram



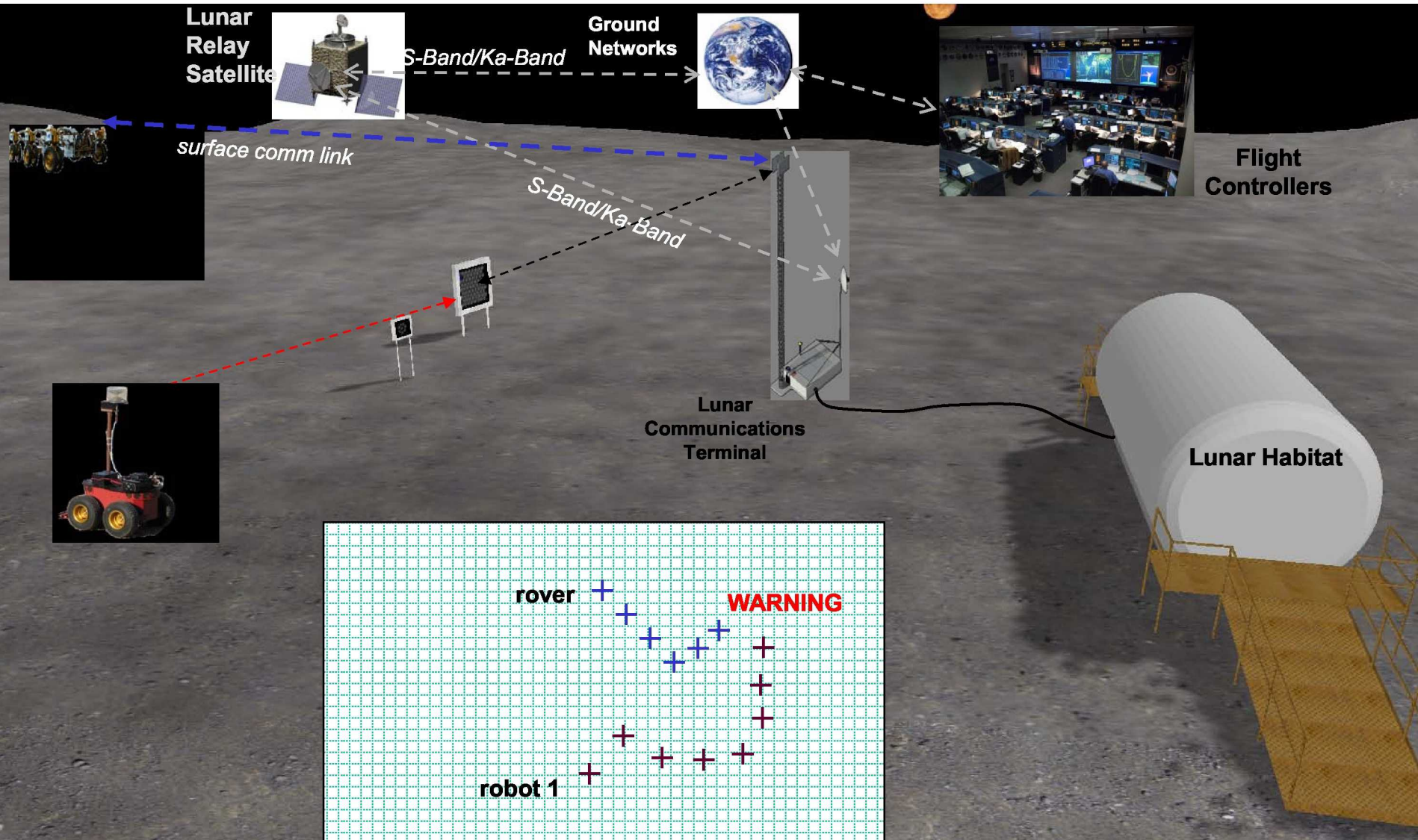


Audio/RFID Scenario at Surface Analog





DTN Lunar Scenario: Navigation Telemetry



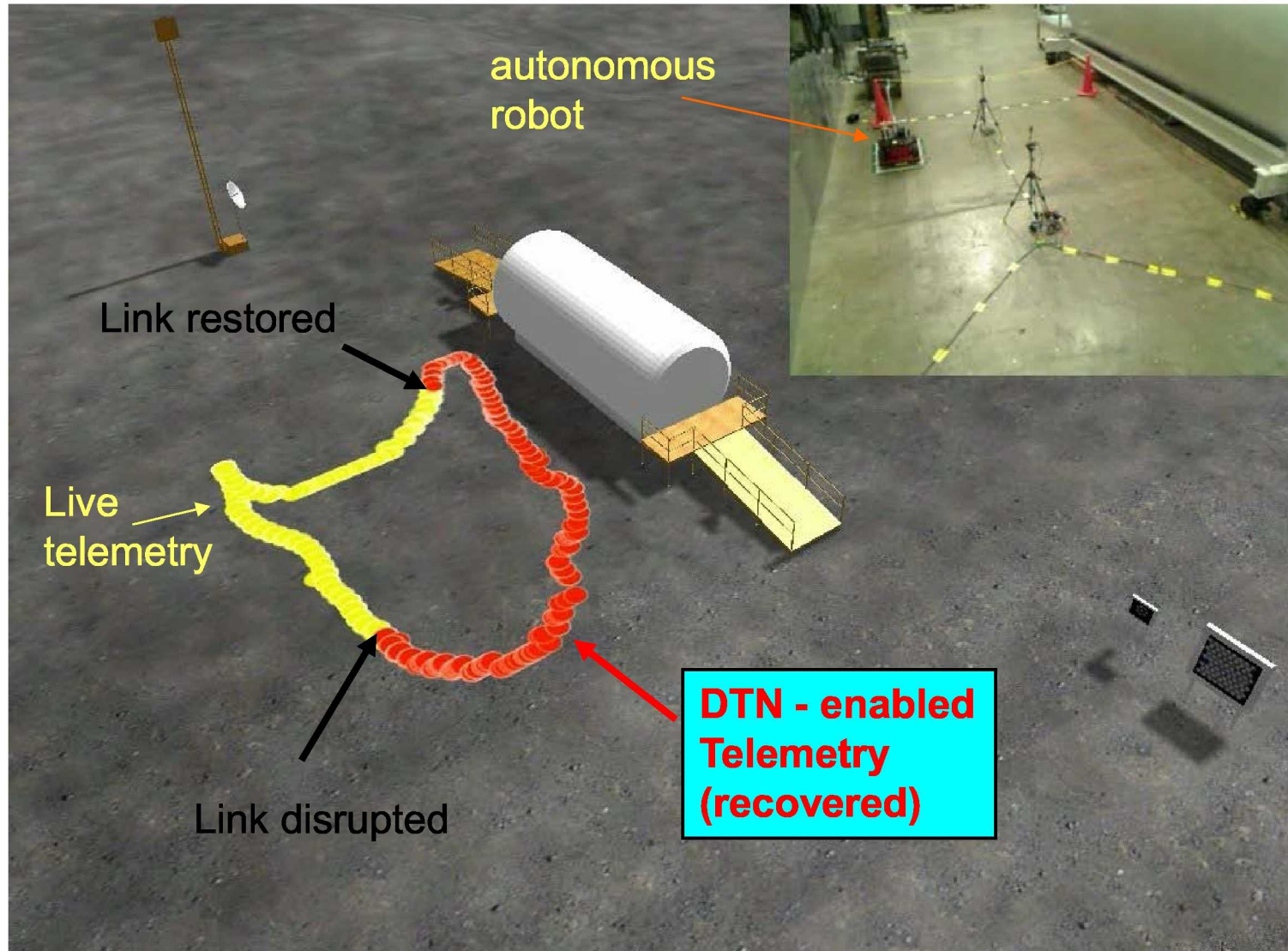


DTN Lunar Scenario: Navigation Telemetry Operations Concept and Value Provided

- **Ground crew views tracking telemetry from autonomous robot in habitat proximity**
- **Tracking telemetry is routed through multi-hop network that is subject to disruptions**
- **DTN technology prevents loss of situational awareness data**
 - Provides “last known location” and promotes anomaly resolution



DTN Lunar Scenario: Navigation Telemetry Demonstration





Conclusion

- **A surface communication analog is under development**

- Experiments and demonstrations can incorporate multiple Constellation element analogs and facilities
- DEN connectivity will permit DTN team members access to wireless communication links

- **Three scenarios are targeted for demonstration in FY10**

- Motion imagery
 - Voice and sensor telemetry
 - Navigation telemetry
-



Backup

DRAFT

